

**Radiological Monitoring of the Raw Sewage, Final Effluent,
Sludge and Biosolids of the
Metropolitan Water Reclamation District of Greater Chicago**

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INTRODUCTION

The discharge of radioactive materials into sanitary sewer systems is regulated by the Nuclear Regulatory Commission (NRC). In Illinois, hospitals, industries, research organizations and other radioactive material license holders are allowed to dispose of radionuclides into the sanitary sewer system in accordance with 32 Illinois Administrative Code: Chapter II, Section 340.1030. Naturally occurring radionuclides from groundwater and stormwater runoff also enter the sewerage system. There have been several reported cases of radioactive contamination in wastewater treatment plants in the United States over the last ten years.

This study was conducted to determine the radioactivity concentration in raw sewage, final effluent, return sludge, anaerobically digested sludge, and biosolids at the seven water reclamation plants (WRPs) owned and operated by the Metropolitan Water Reclamation District of Greater Chicago (District). The radioactivity removal efficiency by the wastewater treatment process at all the WRPs was calculated. The radiological monitoring was conducted to develop baseline data on radioactivity occurring in the District's sewage, sludge, and biosolids.

MATERIALS AND METHODS

Sample Collection

Weekly samples of raw sewage, and monthly samples of final effluent and sewage sludge were collected from the District's seven WRPs. The biosolids samples were collected from eight sludge drying sites of the District. Biosolids refers to the fully processed sewage sludge product destined for final utilization.

Analytical Methodology

GROSS ALPHA AND GROSS BETA RADIOACTIVITY

Gross alpha and gross beta radioactivity measurements were conducted on raw sewage, final effluent, return sludge, anaerobically digested sludge, and biosolids samples. The samples were processed using Standard Methods for the Examination of Water and Wastewater (Standard Methods) procedure 19th Edition. The samples were counted on Tennelec LB5100 alpha/beta gas proportional counter.

GAMMA RADIOACTIVITY

Gamma activity in biosolids samples was determined as follows:

The biosolid sample was dried on a hot plate at low heat. It was then ground and passed through a 30 mesh sieve. The sieved material was packed in a tare 3 oz. canister and weighed. The sample was analyzed by a gamma spectroscopy system equipped with a high-purity germanium detector and GammaTrac software analysis package from Oxford Instruments Inc. The energy and efficiency calibration of the system was verified before the sample was counted using a National Institute of Standards and Technology (NIST) traceable standard.

RESULTS

The average gross alpha radioactivity for the year 1996 in raw sewage, final effluent, and sewage sludge of the District's seven WRPs is presented in Table 1. The gross alpha radioactivity levels in the influent and effluent at all the WRPs were below the detection limit (3.1 to 5.1 pCi/L) except for the influent of the Lemont WRP (12.2 pCi/L). The gross alpha radioactivity removal efficiency could not be calculated because of these below detection limit values. The gross alpha radioactivity in sludge ranged from 3.5 pCi/g dry weight (dw) at the North Side WRP to 4.5 pCi/g dw at the Lemont WRP.

The average gross beta radioactivity for the year 1996 in raw sewage, final effluent, and sewage sludge is given in Table 2. The gross beta radioactivity in the influent ranged from 8.4 pCi/L at the North Side WRP to 26.3 pCi/L at the Lemont WRP. The gross beta radioactivity in the effluent ranged from 5.8 pCi/L at the North Side WRP to 12.2 pCi/L at the Lemont WRP. The estimated gross beta radioactivity removal efficiency ranged from 28.4% at the Stickney WRP to 53.6% at the Lemont WRP. The gross beta radioactivity in sludge ranged from 13.2 pCi/g dw at the John E. Egan WRP to 50.5 pCi/g dw at the Lemont WRP.

Table 3 presents the gross alpha and gross beta radioactivity levels in District biosolids in 1996 from various sludge drying sites of the District. The average gross alpha radioactivity levels ranged from 5.1 pCi/g dw at the Vulcan drying site to 7.1 pCi/g dw at the LASMA drying site. The average gross beta radioactivity levels ranged from 22.4 pCi/g dw at the Vulcan drying site to 27.5 pCi/g dw at the Marathon drying site.

In 1996, eight biosolids samples, obtained from various District sludge drying sites, were analyzed for 24 specific radionuclides. The radionuclides were selected from a table of radionuclides of concern in remediated soil prepared by United States Environmental Protection Agency (USEPA Office of Radiation and Indoor Air). Of these radionuclides, only three were detected at measurable levels. These were potassium-40, cesium-137, and radium-226 (Table 4). The potassium-40 levels ranged from 7.0 pCi/g dw at the Calumet West drying site to 10.4 pCi/g dw at the Ridgeland drying site. Radium-226 levels ranged from 3.6 pCi/g dw at the Stony Island and Vulcan drying sites to 4.5 pCi/g dw at the Calumet East and Calumet West drying sites. The cesium-137 levels ranged from 0.2 pCi/g dw at the Calumet East drying site to 0.6 pCi/g dw at the Ridgeland drying site.

Yearly Average of Gross Alpha Radioactivity in Raw Sewage, Final Effluent, and Sludge From the District's Seven WRPs and Radioactivity Removal Efficiency of the WRPs - 1996

WRP	Raw Sewage (pCi/L)	Final Effluent (pCi/L)	Radioactivity Removal Efficiency	Sludge (pCi/g dw)
Stickney	<3.8	<3.1	-*	5.3
Calumet	<3.7	<3.5	-	5.9
North Side	<3.3	<3.1	-	3.5
John E. Egan	<3.6	<3.2	-	5.6
Hanover Park	<3.4	<3.1	-	4.7
James C. Kirie	<3.7	<3.4	-	5.0
Lemont	12.2	<5.1	-	45.3

*Cannot be calculated because of below detection level values.

TABLE 2

Yearly Average of Gross Beta Radioactivity in Raw Sewage, Final Effluent, and Sludge From the District's Seven WRPs and Radioactivity Removal Efficiency of the WRPs - 1996

WRP	Raw Sewage (pCi/L)	Final Effluent (pCi/L)	Radioactivity Removal Efficiency (%)*	Sludge (pCi/g dw)
Stickney	12.0	6.0	50.0	22.8
Calumet	9.5	6.8	28.4	21.9
North Side	8.4	5.8	30.9	15.0
John E. Egan	10.8	7.0	35.2	20.4
Hanover Park	9.6	6.4	33.3	13.2
James C. Kirie	11.4	7.8	31.6	16.8
Lemont	26.3	12.2	53.6	50.3

*(Raw Sewage - Final Effluent) x 100/Raw Sewage.

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TABLE 3

Gross Alpha and Gross Beta Radioactivity of District Biosolids During 1996

Drying Site	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	6	7.1	5.8	9.8	23.0	21.5	25.3
Calumet	5	6.7	6.4	7.5	22.7	20.6	27.3
HASMA	5	5.7	5.3	6.4	23.8	21.3	29.4
Marathon	1	6.6	6.6	6.6	27.5	27.5	27.5
122 nd Stony	8	6.1	5.2	7.1	22.5	18.9	26.9
Vulcan	7	5.1	3.9	6.3	22.4	20.3	25.9
Ridgeland	1	5.6	5.6	5.6	24.2	24.2	24.2

TABLE 4

Concentration of Gamma-Emitting Radionuclides in District Biosolids During 1996

Drying Site	Potassium-40 (pCi/g dw)	Radium-226 (pCi/g dw)	Cesium-137 (pCi/g dw)
Calumet East	7.4	4.5	0.2
Calumet West	7.0	4.5	0.3
Ridgeland	10.4	4.0	0.3
Stony Island	8.6	3.6	0.6
HASMA	9.6	4.1	0.4
LASMA	9.0	4.3	0.4
Marathon	9.7	3.9	0.4
Vulcan	9.9	3.6	0.4

CONCLUSION

The analytical data demonstrates that radioactivity in the final effluent of all the WRPs is generally lower than the corresponding raw sewage of the WRP. This indicates that the wastewater treatment process is removing radioactivity from the raw sewage.

The amount of gross alpha and gross beta radioactivity in the final effluent is less than the allowable contaminant levels in community water standards set by the USEPA National Primary Drinking Water Regulations, 40 CFR Part 141. The USEPA limit for gross alpha radioactivity (including radium-226 but excluding radon and uranium) is 15 pCi/L and for gross beta radioactivity it is 50 pCi/L. The gross beta radioactivity in the final effluent is also less than the General Use Water Quality Standard (100 pCi/L) of the Illinois Pollution Control Board (IPCB) (Title 35, Chapter 1, Section 302.207). There are no IPCB standards for gross alpha radioactivity in General Use waters.

Measurable concentrations of gross alpha and beta radioactivity were found in biosolids samples examined from all the sludge drying sites of the District. The average gross alpha radioactivity of biosolids from these sites ranged from 5.1 pCi/g dw to 7.1 pCi/g dw. The average gross beta radioactivity ranged from 22.4 pCi/g dw to 27.5 pCi/g dw.

One biosolids sample from each District sludge drying site was further analyzed for 24 specific radionuclides by gamma spectroscopy. Of these, only potassium-40, radium-226, and cesium-137 were detected in measurable quantities. Two of these radionuclides, potassium-40 and radium-226, are of natural origin. The third radionuclide, cesium-137, is a man-made radionuclide and may have arisen from fallout of nuclear weapons testing.

Potassium-40, radium-226, and cesium-137 activities ranged from 7 pCi/g to 10.4 pCi/g, 3.6 pCi/g to 4.5 pCi/g, and 0.2 pCi/g to 0.6 pCi/g, respectively, in the biosolids analyzed. Currently, there are no USEPA standards for the radioactivity in biosolids.